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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

THE RESEARCH AND DEVELOPMENT ENGINEER AS A MANAGER: AN ANALYSIS OF THE MANAGEMENT DEVELOPMENT NEEDS OF ENGINEERS AT THE NASA MANNED SPACECRAFT CENTER

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FOREWORD

This study was undertaken as part of the Resident Research Fellowship Program co-sponsored by the Manned Spacecraft Center and the College of Business, Oklahoma State University. The finished report has been submitted to Oklahoma State University as a thesis which will partially fulfill the requirements for the degree of Master of Business Administration. The Resident Research Fellowship Program is designed to provide university graduate students with the opportunity of broadening their experience and conducting research in an actual R&D organization.

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CHAPTER I

INTRODUCTION

In a study which has as its purpose determining engineers' qualifications as managers and identifying their specific needs for improvement in management skills, a logical first step would be to define management and determine what knowledge and abilities are requisite to effective management. A review of some of the literature on the activities and characteristics of managers produces, however, a wide range of statements concerning what managers do and what qualifications or abilities are necessary to succeed or be effective as a manager. Those few generalizations which can be made are of little use in answering questions about a specific organization or group of managers. The diversity found in the literature may indeed be an indication that generalizations in these areas cannot be useful beyond the particular organization or managers studied.

While this study wishes to recognize the need for more research on the activities and qualifications of effective managers, it in effect jumps over these unanswered questions and attempts to compensate by seeking answers only for the particular organization that is studied. This is done in an effort to provide one organization with some useful answers to a question of increasing importance to many organizations: how to best prepare a technically trained man for a management position.

Both experience and intuition indicate that the individual with an engineering education and background may have some deficiencies in terms of the skills and knowledge needed to be an effective manager. The transition from engineering to management involves a change from problems that can usually be solved by quantitative methods to problems that almost invariably contain some qualitative factors, and a change from primarily individual responsibility to responsibility for others' efforts and a greater need for interaction with others. Very little has been done in identifying and measuring the deficiencies produced by these transitions, and the resulting needs for development.

To the National Aeronautics and Space Administration's Manned Spacecraft Center, these questions are of particular significance for it is inevitable that a large portion of the management jobs in this organization will be filled by individuals with engineering education and technical experience. At the time of this study, the Manned Spacecraft Center employed approximately 2300 persons in engineering jobs, and of these, about 65 percent had bachelor's degrees in engineering fields.[1] These

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[1]Total figure is for persons with 700 series NASA job codes, from personnel file, Feb. 1968; percentage with engineering degrees estimated from sample.

figures, representing a large fraction of the Center's total employment, and the technical nature of many management jobs at MSC indicate that a large number of management positions will continue to be occupied by engineers.

Other factors also emphasize the need for developing management ability in these technical personnel. The fact that the Manned Spacecraft Center is a relatively young organization just beginning to experience the effects of its growth and aging, and the nature of the mission of MSC as both complex and changing point up the necessity of developing good managers for the coming years.

The present program for management development at MSC consists of a group of one- to two-week courses in communications skills and general management that are taught by either the Civil Service Commission or contractors.[2] These courses are offered periodically and, with the exception of the courses in communications skills, are usually limited to supervisors. Some efforts have been made at planning for the development of groups of individuals within some organizational units, but in general there is no comprehensive plan for developing management ability in engineers. In many cases, participation in courses is determined more by the individual's expected work load than his need for training.

The requirements for developing technical personnel into managers and the present status of management training at the Manned Spacecraft Center have indicated a need for an objective basis for determining the content of management education to be offered and the structure of programs to be used for developing future managers. It is hoped that this study will provide such a basis.

Purpose

The primary purpose of this research project was to determine what the average engineer at the Manned Spacecraft Center lacks in abilities and knowledge required to be an effective manager. A secondary objective was to determine specifically what management training and development should be used to reduce these deficiencies and to whom it should be applied.

Working toward these objectives required that several other questions be answered. First, what knowledge and abilities are required to be a manager at the Manned Spacecraft Center, and which of these are most important? Second, what is the deficiency of the average engineer in each

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[2]For a complete list of courses now offered, see Appendix A.

of these areas? Third, what are engineers' attitudes towards a management career? Fourth, when do they develop these attitudes and why?

Two aspects of these objectives require some clarification. First, as noted above, the role and activities of management may vary widely between organizations. Thus, the results and recommendations of this study will have applicability to engineers in other organizations to the extent that the role and activities of management and the type of engineer brought into the organization are similar to those of the organization being studied here. Second, by answering the above questions for the average engineer, it is not intended that management development should include all engineers. Development must be an individual process, and once broad programs are established, engineers' needs within this framework should be determined individually. The purpose of this study is to provide a basis for the content and priorities of a total program which will meet the needs of most individuals.

Scope

The scope and limitations of this research project can be defined and explained by the following statements:

1. The group studied consists primarily of persons with both engineering education and engineering work experience.

2. The type of management emphasized in the study is management of technical personnel working toward primarily technical goals.

3. Although its primary research emphasis is on the content of a formal management education program, the study is intended to encompass the total scope of methods used to improve the ability of managers or potential managers. The word "development" is used in the title of the report to indicate the inclusion of both the formal and informal methods that may be used. In the literature, the words "education", "training", and "development", are often used with slightly different meanings, but are also used interchangeably in many cases. In this report, whether the words "training", "education", or "development", or combinations are used, the intent is to include all aspects of improving managers' performance.

4. The study encompasses both educational needs and attitudes. If the premise is adopted that motivation must precede effective learning, then the objectives of the study require than an effort be made to determine how many engineers are motivated to enter management careers.

5. The management abilities of engineers are studied in absolute terms, i.e., the engineer is compared to the theoretical "good manager". No attempt is made to compare the management deficiencies of engineers

to those of prospective managers of other educational backgrounds, although the results of the study may have some implications for such a comparative study.

6. The study focuses primarily on management abilities to which education and training can be related. It is not a study of personality traits, nor is it intended to provide a basis for selecting or identifying potential managers. Instead, the emphasis is on what should be done to improve the ability of the individual who has been selected.

7. The study has the limitations inherent in any project which deals with the measurement of human behavior. It should thus be realized that a project which attempts to identify and measure variables in the area of management has at its outset severe limitations in objectivity. In addition, the limitation of time (four months) was a significant consideration in determining the amount and type of research that could be done.

8. The primary method of research for the project was a questionnaire circulated to 330 engineers employed by NASA at the Manned Spacecraft Center. Other methods used included a literature search, interviews, observation of some present management training courses, and presentation of preliminary results and discussion of these results with management.

Plan of Development

Including this introductory chapter, the report is presented in six chapters. Chapter II will summarize the literature that was reviewed as applicable to the purpose of this project, with emphasis on previous studies of the educational needs of engineers. Chapter III on methodology covers selection of the survey questionnaire as the primary method of research for the project, the design and rationale of the questionnaire, and the sampling procedure used.

Because it is felt that there is a significant need for more research in this area and thus that the most significant contribution of this project may be its possible value to future studies in the area, considerable space is devoted to discussion of the methodology used in the study.

In Chapter IV, the major results of the questionnaire survey will be presented, and possible reasons for and implications of these results will be given. Finally, in Chapters V and VI, conclusions will be drawn from the research that has been done and recommendations will be made where applicable. The chapter on conclusions is intended to be somewhat more applicable to engineers in general than the recommendations chapter, which is presented primarily in terms of management training at the Manned Spacecraft Center.

CHAPTER II

LITERATURE SURVEY

Qualifications for Effective Management

As pointed out earlier, the basis of this research project should logically be an understanding of what managers do and what knowledge and skills are needed to perform as managers. The literature contains an almost unlimited number of different lists and classification systems for what supervisors, managers, or executives must be, must do, or must know. A few examples should illustrate the diversity which is found.

One author lists a total of more than 30 desirable characteristics under the following categories: personal traits, mental capacities, social skill, physical attributes, and attitudes.[1] Another list includes leadership, courage, judgment, imagination, integrity, general and specialized knowledge, depth of interest, and a desire to get the job done.[2] A third list which focuses more on skills than personality traits lists these skills: reading, general communication, human relations, interviewing, counseling, working with groups, and delegation.[3] In addition to these and many other lists of characteristics or qualifications for good managers, there are the textbook definitions of management as planning, organizing, directing, and controlling, or as accomplishing things through other people.

Although there is certainly a need for more research and more objective answers to questions in these areas, the seeming confusion about qualifications of managers is not totally the result of a lack of knowledge. Methods of classifying and defining the job of manager will necessarily vary with their purpose, and results of studies will vary depending on the specific types of organization or managers studied. The value of the description of management used in this study should then be determined by its applicability to the people and organization being studied and its appropriateness for the purpose of determining management training

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[1] Eugene J. Benge, How to Become a Successful Executive (New York: Frederick Fell, Inc., 1960), p. 16.

[2] William B. Given, Jr., "The Engineer Goes Into Management," Harvard Business Review, XXXIII (January-February, 1955), pp. 48-49.

[3] Roger Bellows, Thomas Q. Gilson, and George S. Odiorne, Executive Skills: Their Dynamics and Development (Englewood Cliffs, N. J.: Prentice-Hall, Inc.

requirements. The list of areas of managerial ability and knowledge used in the project was designed with the various lists offered by the literature as a background, and with applicability to specific education and training areas and to the MSC organization as its goals.

Engineers as Managers

Although there is a great deal of material available on such topics as the management of engineers and scientists, the realtionships of engineers to management, the behavior of professionals in organizations, and the career development of engineers and scientists, much of which indirectly relates to this study, relatively little has been written on the specific topic of developing engineers into managers.

The few articles that have been written on this subject cite little evidence other than casual observation and experience. However, a few observations appear repeatedly and may thus be worth considering. The most common statement found is that the engineers' background of scientific method and emphasis on exactness and a detailed, quantitative decision making process may hinder him in dealing with the subjective aspects of many decisions and in working with people.[4] It is generally agreed that, to become a good manager, the average engineer must be reoriented from working with things to working with people and must learn to make managerial decisions. It has also been pointed out, however, that engineers are in some aspects well-qualified as managers. Their training in handling problems objectively can be an asset if they realize that there is often a compromise between exactness and time. And as professionals, they have the sense of integrity that is often considered essential to being a good manager.[5]

As for the engineer's motivation to become a manager, it has been stated that the college student today is in many cases attracted to an engineering career because of the promise of prestige, money, and professional achievement.[6] These motives are not incompatible with the rewards offered by management careers, so there is reason to believe that many engineers may be motivated toward management careers.

These generalizations which can be made about the relatively small amount of work done in evaluating the engineer's qualifications as a

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[4]Given, "The Engineer Goes Into Management", pp. 44-45.

[5]George S. Odiorne, "Making Managers out of Engineers," Personnel, XXXIII (November, 1956), pp. 259-266.

[6]Perry A. Constas, "Engineering Education and the Engineer's Self-Image," Personnel Journal, XLV (March, 1966), p. 154.

manager have been helpful as background material for this study, but unfortunately have been of little value in answering the more specific questions posed by the study.

Management Training and Development

A great many books and articles have been written on the subject of developing managerial ability, and a great many programs and methods, both formal and informal, have been and are used by organizations to improve the quality of management. At this point in the relatively short history of formalized management development, it has not been shown that there is any one best method of improving management ability. For many types of training and development, if fact, there has been no positive proof that improvement results. These facts are at least partially the result of difficulties of measurement, but they demonstrate that methods to be used are largely dependent on individual situations, and that in many cases the benefits to be realized from the resources allocated to training may not be subject to measurement.

The various methods of development can be classified as those used on the job while the individual is engaged in productive work, and those used while he is away from the job. The most common method of on-the-job development is the conscious development of an individual by his superior by coaching, varying assignments, and encouraging the subordinate's self-development. Other on-the-job methods include job rotation, special projects, and committee assignments.

Methods of development used away from the job include full-time or part-time university work, short courses, role playing, sensitivity training, lectures, special meetings, and numerous other techniques. University work and short courses taught either by the organization or an outside concern are probably the most common.

One author notes that there is a trend away from the use of formal management development programs and toward more emphasis on giving line managers the responsibility for developing their subordinates, as companies discover that some aspects of management may be taught better by this method than by formal education programs.[7] It would appear that the best program for improving management ability would not exclude either type of development. There should be both an emphasis on the development which can be produced on the job through the supervisor's guidance and an availability of educational opportunities. In an organization like the Manned Spacecraft Center in which schedules and deadlines

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[7]Robert K. Stolz, "Executive Development - New Perspective," Harvard Business Review, XLIV (May-June, 1966), p. 133.

often preclude taking time away from the job for training, an emphasis on conscious efforts by managers at developing subordinates while on the job seems imperative if the quality and effectiveness of future managers is to be increased.

In designing a program of formal education to be used, the results of research on learning can provide valuable guidelines. A great amount has been learned in this area, and much of it has implications for the design of a short course program such as that offered at the Manned Spacecraft Center. The authors of one book on executive development list several principles for development that are based on what is known about learning. Three of these principles seem especially applicable to the structure of the present MSC program and will thus be cited here with some additional comments:

1. Learning takes place more rapidly when one expects to use the results of the learning.

2. The plan for learning should take into account present knowledge and skill.

3. For learning that requires practice, some distribution of practice is better than massed practice.[8]

The first of these principles emphasized the importance of motivation to learning. It implies that no attempt should be made to develop into managers those engineers who are not motivated to become managers. It also implies that training will be more successful if the people involved are shown why they need to learn and how they will be able to use what they learn. The second principle indicates that courses should be made more applicable to the organization for which they are taught and that their design must consider the educational background and the present knowledge of the average engineer. The third statement might seem to have little applicability to management training courses where little actual "practice" is involved. However, the research on which this principle is based may also be applicable to situations in which a large amount of material is presented in a relatively short time. Thus, 40 hours of instruction in management theory and skills might be more effective if distributed over several weeks than if massed into five consecutive 8-hour days. Of course, economic considerations would be important in determining whether this method would be practical.

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[8]Rober Bellows, Thomas Q. Gilson, and George S. Odiorne, Executive Skills: Their Dynamics and Development (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1962), pp. 31-38.

Educational Needs of Engineers

Previous studies have dealt with the broad educational needs of engineers rather than specific management training needs and have had the purpose of making recommendations for future engineering curricula or determining broad needs for continuing education. These studies are of little value when determining specific needs for management education, but are helpful in providing some perspective. Applicable to the purpose of this study are three recent studies conducted by Dubin and Marlow of Pennsylvania State University,[9] by the Joint ECAC-RWI (Engineering College Administration Council and Relations with Industry) Divisions of the American Society for Engineering Education,[10] and by the Goals Study Committee of the American Society for Engineering Education.[11] These studies included questionnaire responses from approximately 2000, 3000, and 4000 engineers, respectively.

The first two of these studies focus on engineers' self-perceived needs for continued education, asking whether the respondent "should have or could use" or "feels a need for" further training in particular subjects, while the Goals Study Committee's study asked for the engineer's opinion as to whether various subjects should be included in future engineering curricula, whether the individual had received any formal training in the subject, and how often the subject was used in his work.

The Goals Study report is difficult to compare to the other two studies because of these differences in methodology and differences in the lists of courses used. The Goals Study questionnaire used a list of 44 subjects, 12 of which could be considered non-engineering subjects. Four of these subjects are of particular interest to this project. "Industrial management" was recommended for future use in engineering curricula by 78 percent of the respondents, ranking it 30th among the 44 subjects. However, the 51 percent who had not received formal training in industrial management, but recommended it for future use, was the largest figure for

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[9] Samuel S. Dubin and LeRoy Marlow, "Research Report of Continuing Education for Engineers in Pennsylvania," Continuing Education, The Pennsylvania State University, 1965, cited by Fred Landis, Engineering Obsolescence and Continuing Education, Report to the Office of University Affairs, National Aeronautics and Space Administration, July, 1967 (New York: New York University, 1967), p. 33.

[10] American Society for Engineering Education, "Education in Industry," Journal of Engineering Education, LV (May, 1965), pp. 254-256.

[11] William K. Lebold, Robert Perucci, and Warren Howland, "The Engineer in Industry and Government," Journal of Engineering Education, LVI (March, 1966), pp. 237-274.

any of the subjects. A course in speech was ranked 6th, recommended by 96 percent. English composition was ranked 3rd, with 99 percent recommending, and economics ranked 20th with 89 percent.

In the ECAC-RWI study a list of 123 subjects was used. The subjects were gathered into 10 academic areas, six of which were engineering and science areas. In this study, "management practices" was th most popular subject for further study, being selected by 65 percent of the respondents. Courses in the areas of communications and management made up 8 of the 10 subjects perceived as most needed. Included among these were "technical writing" (64 percent), "public speaking" (60 percent), "working with individuals" (57 percent), "working with groups" (55 percent), "speed reading" (54 percent), "talking with people" (53 percent), and "business practices" (51 percent).

In the Pennsylvania State University study, human relations and communications skills were perceived as the most important areas for further education. Seventy-six percent of the engineers desired courses in communications skills. Economics (63 percent) and management (56 percent) were next. In this and the ECAC-RWI study, engineers perceived their needs for further technical training as secondary to these areas.

These three studies are consistent in indicating both that engineers are quite interested in management activities and that they feel a need for education and training in communications and other management skills. All three studies indicate a definite need for more training in communications skills, especially speech. In the Pennsylvania State and ECAC-RWI studies, engineers emphasize their preference for management training over technical training. The fact that technical training is ranked higher in the Goals Study report could be attributed to the fact that this study asked for recommendations for engineering curricula rather than self-perceived needs for further education.

CHAPTER III

METHODOLOGY

The use of a mailed questionnaire to a sample of MSC engineers was decided upon as the primary method of gathering the data needed for the study within the time available for research. A copy of this questionnaire may be found in Appendix A. Since it is felt that any mailed questionnaire has some limitations in objectivity, the alternative measurements that were considered will be discussed briefly.

Selection of Research Method

Before the survey questionnaire was selected, several other sources of data were considered: performance evaluations, promotions, records of courses taken, testing, and personal interviews. The alternative of sampling files of evaluations of engineers' performance for indications of strengths and weaknesses in management ability was eliminated for several reasons. First, the type of performance evaluations used at the Manned Spacecraft Center are such that they would not have provided much useful information about the skills and abilities that are of interest to this study. Second, as has been pointed out by Sayles,[1] the employee evaluation is at best still a very subjective method. Finally, even if these evaluations could have provided an objective measure of engineers' abilities, there would have remained the problem of determining the relative value and need for each of these abilities or areas of knowledge.

A second available source of data was the record of management courses taken by individuals. These records could have been correlated with the employees' promotion records or performance evaluations. This method would have several shortcomings. First, since management training courses are taken primarily at the employee's initiative at the Manned Spacecraft Center,[2] a high correlation with promotions could have been expected, assuming that those who were motivated to educate themselves in management skills were also more oriented toward advancing into management. Second, it was felt that promotions would not be a reliable indication of ability.

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[1] Leonard R. Sayles, Managerial Behavior; Administration in Complex Organizations (New York: Mc-Graw-Hill Book Company, 1964), p. 16.

[2] Of the 96 questionnaire respondents who had participated in management training courses, 62 percent reported having taken these courses primarily at their own initiative.

The alternative of using tests to determine engineers' knowledge and aptitude in management is felt to be the most objective way of measuring engineers' abilities and potential as managers. If tests with demonstrated validity and reliability, designed to measure knowledge and skill in management areas, could be administered to a group of engineers and to a control group consisting of managers who are judged by some criterion to be effective managers, it is felt that the differences which could be noted would provide an objective and fairly reliable indication of the management training needs of engineers. However, several considerations pointed to this method as an ideal measurement which may be applied at some future time rather than a method which was feasible in the present study. Tests are available to measure general intelligence, personality characteristics, motivation, and achievement in educational subject areas and occupations. A test has even been developed to measure "proficient knowledge" of the manager-supervisor occupation.[3] Conceivably then, a battery of tests could be selected to measure the ability of engineers as managers, with the possible exception of a few aspects of management activity. However, in order to select the proper tests, one would first have to determine just what abilities and knowledge are required by the manager. In the present study this general method of measurement was rejected because of the difficulties which would be encountered, because of the lack of the necessary control group described above, and because of the time limitations of this research.

The personal interview could have been used to gather essentially the same type of information as the questionnaire with the possible advantage of gaining a better understanding of responses and thus limiting the range of interpretations that would have to be made. However, due to time limitations, this method could not have been used to reach nearly as large a sample as could be done with a mailed questionnaire nor could the same range of information have been gathered by a reasonably short interview.

It was thus decided to rely on the questionnaire as the primary method of research and to use a limited number of interviews to gain explanatory information. In addition to these methods, observations of present management training courses and presentation and discussion of questionnaire results with management served as supplementary sources of information for the report.

The survey questionnaire used has the advantage of gathering a large amount of data from a large sample in a relatively short time. It also

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[3] Charles V. Youmans, "Testing for Training and Development," in Training and Development Handbook, ed. by Robert L. Craig and Lester R. Bittel (New Yori: McGraw-Hill Book Company, 1967), p. 78.

has the advantage of providing some measurement of the relative value of various areas of management activity so that conclusions can be based on both the engineer's ability in a particular area and the relative need for proficiency in that area rather than on a simple measure of his ability. The questionnaire has the disadvantage of being somewhat lacking in objectivity, as it relies on the individual's self-perception and his perceptions of his managers. It is likely that neither of these perceptions represents reality precisely, but it will be argued that the use of both provides more reliable results than the use of either one alone.

Development and Structure of Questionnaire

Preliminary Design and Testing.- The questionnaire used in this study was designed specifically for the problem at hand since no proven questionnaires were found which would furnish the data needed. An effort was made to acquire information on all questions within the project's scope using a single questionnaire for all engineers, both supervisory and non-supervisory. A preliminary questionnaire was tested on engineers of three different supervisory levels, and improvements were made on the basis of suggestions from these engineers and from personnel concerned with management training. A copy of the final questionnaire with summary results may be found in Appendix A. The structure and rationale of the various questions included can be discussed under two categories: deficiencies in management ability, and career goals and attitudes.

Determining Deficiencies in Management Ability.- In identifying and measuring deficiencies in management ability, it was felt that conclusions should be based on the difference between the individual's ability in a specific area and the ideal amount of ability required in this area. An example should illustrate the difference between this approach and that of using only the first of these two measurements. Suppose that a study reavealed that engineers were weakest in the area of written communication but were fair in their knowledge of operations research techniques. Using this knowledge, the conclusion would be that more training resources should be allocated to improving these engineers' writing ability than to any other area. However, if the same study had also indicated that these managers did very little writing but that quantitative decision making was the very essence of management in this organization, the implications for management training would be quite different.

This reasoning lead to the use of section II of the questionnaire, which asks the respondent to indicate the relative importance of each of a list of management abilities. For the same list, he is then asked first to evaluate his own ability and then the ability, in general, of his managers. It is felt that the difference between this ideal or importance rating and the engineers' ability is the best basis for determining priorities for the allocation of training resources.

The list itself is intended to be as inclusive as possible of abilities required of managers at the Manned Spacecraft Center, focusing on areas to which training can be related (as opposed to personality traits), while also considering the brevity and simplicity that are desirable in a mailed questionnaire. It no doubt excludes items found on other lists of abilities and knowledge required for effective management and includes others that many lists do not include.

Section IV, asking the respondent's opinion of his managers, was included because of the desirability of having a check for the respondent's self-perceptions as an indication of training needs. Research has indicated that supervisors and subordinates often have different perceptions. An example is Mann's finding that 76 percent of the foremen in an organization reported that they consult with their subordinates about job problems but that only 16 percent of the subordinates reported being consulted.[4] In the present study, the average respondent's self-evaluation was about 10 percent higher than his evaluation of his managers. No precise statement can be made about the relationship of reality to these two evaluations, but logic would seem to indicate that it lies somewhere between the two. In drawing conclusions from the questionnaire results, the average of these two evaluations was used.

In addition to these three sections, section VII of the questionnaire was also used to gather information on deficiencies in management ability. This part of the questionnaire asks the respondent to select from a list of educational subject areas those courses which could be of use in his work and in which he has a definite need for further training.

Determining Career Goals and Attitudes of Engineers.- To determine the needs of a group of engineers for management training and make recommendations for management development programs to be used, it was necessary to attempt to discover the career goals and attitudes of the average engineer. Section V contains questions relating to the engineer's career goals with respect to management and the reasons he perceives for his preference of either an engineering or a technical management career. The primary goals of this section of the questionnaire were to determine whether the problem exists of motivating engineers to become managers and to discover engineers' reasons for wanting or not wanting to become managers.

Section VI includes questions designed to measure the respondent's feelings about the role of management education and training in developing managers. The respondents were also asked to evaluate the management

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[4] Robert L. Kahn and Daniel Katz, The Social Psychology of Organizations (New York: John Wiley and Sons, Inc., 1966), p. 189.

courses they had already taken and were asked for any suggestions regarding the general purpose of the study.

Selection of Sample

Population.- It has been discussed earlier that one of the goals of this study was to make recommendations regarding the total population of engineers at the Manned Spacecraft Center. For this reason, it was decided that the sample selected should be representative of this total population. Using this strategy would also allow comparing the results from various sub-groups, e.g., supervisors versus non-supervisors.

The Manned Spacecraft Center is organized into seven directorates, two program offices and four other offices. Those directorates and offices which contain engineers are listed at the top of the columns of table I. To provide the information in table I, a listing was obtained of all individuals in engineering jobs at the Manned Spacecraft Center as determined by their NASA job code. This table summarizes the numbers of engineers located in each major organizational unit by GS-levels 7 through 16. For purposes of simplicity, four organizational units (Administration, Medical Research and Operations, Flight Safety, and Reliability and Quality Assurance) were eliminated from the population either because of their relatively small number of engineers or, in the case of Administration, because most of the engineers in this directorate are concerned with maintenance of the Manned Spacecraft Center. It was decided to use a stratified random sample of the resultant population with each of the hierarchical levels 7, 9, 11, 12, 13, 14, 15, and 16 comprising a stratum. This method of stratification was selected because of the expectation that results would be more variable among these levels than any other divisions which could be made. Also, using this method, an effort could be made to control the size of the samples from each of these levels so that results from the various levels could be compared.

Sample Size.- Having determined that the sample would be selected randomly and in proportion to the numbers of the total population in each of the levels GS-7 through 16, the only decision remaining was that of total sample size. In order to make a totally rational decision about sample size, some estimate must be made of the variability of the population. However, since this research questionnaire contained a large number of diverse questions, including some subjective ones, no single meaningful measure of variability could be selected. Sample variances could have been calculated for individual items, but the number of subjects included in the pretest was not sufficiently large, and time prohibited using a larger scale pre-testing procedure.

The sample size used was finally determined on the basis of the following considerations. First, the total sample size would be limited by

TABLE I.- MSC ENGINEERS (700 SERIES JOB CODES) BY GRADE LEVEL AND DIRECTORATE OR OFFICE

Directorate or Office	Totals
Engineering and Development	933
Flight Operations	600
Science and Applications	175
Medical Research and Operations	26
Flight Crew Operations	227
Administration	77
Apollo Spacecraft Program Office	158
Apollo Applications Program Office	55
Flight Safety Office	4
Reliability and Quality Assurance Office	27

GS Level	16	15	14	13	12	11	9	7	
Totals	27	211	390	633	370	303	225	124	2273

the resources available for sampling, a significant consideration in any sample size decision. The critical factor in this case was the time available for scoring, tabulating, and analyzing the completed questionnaires, and it was estimated that no more than 200 could be handled. Second, a return percentage of from 50 to 60 percent of those questionnaires mailed out was expected. Finally, a minimum sample of 30 was desired from each of the following five groups: GS-7 and 9; GS-11 and 12; GS-13; GS-14; GS-15; and GS-16. (Examination of sampling tables reveals that increase in accuracy is relatively small beyond N=30.) Using these guidelines, a total sample of 330 was decided upon, divided as indicated in table II.

Sample Return and Reliability.- Of the 330 questionnaires mailed, 191 (58 percent) were returned in time to be included in the results of this study. The numbers received from each of the six organizational units included and from each of eight GS-levels are roughly proportional to the numbers in these same categories in the total population as shown in table III.

To provide an indication of the reliability of the resulting sample, variances were calculated for some of the questionnaire items. The most variable item found was item 1 in section II, the respondents' opinions of the relative importance of technical knowledge, which had a standard deviation of 2.03. One simple statement of the reliability of the results for this particular item would be that one can be 95 percent confident that, if the entire population were surveyed, the resulting average score for this item would be within a range of .26 (on the 10 point scale used) above and below the average score given the item by the sample group. The least variable item found was item 7 in section II, with a standard deviation of 1.17. Stated in the above terms, one is 95 percent confident that the true population mean is within $\pm$.15 points of the sample mean.

In general, responses evaluating managers were more variable than those for self-evaluations, thus the results for self-perceptions are somewhat more statistically reliable. Also, results for subgroups of the total sample will be less reliable than those for the entire sample.

To summarize the reliability of the sample on which the conclusions of this report are based, it can first be stated that the structure of the resultant sample is representative of that of the total population of engineers at the Manned Spacecraft Center. Second, although a complete statistical analysis was not performed, the checks which were made indicate that the sample is large enough to be statistically reliable in statements about the total population.

TABLE II.- SAMPLE SIZE FOR MAILED QUESTIONNAIRE

GS Level	Number in Sample
16	10
15	40
14	55
13	80
12	45
11	40
9	30
7	30
Total	330

TABLE III.- PERCENTAGE OF SAMPLE VS. PERCENTAGE OF POPULATION CONTAINED IN VARIOUS CLASSIFICATIONS

Directorate or Office	Percentage* of returned sample	Percentage* of population
Engineering and Development	55	44
Flight Operations	25	28
Science and Applications	3	8
Flight Crew Operations	8	10
Apollo Spacecraft Program	7	7
Apollo Applications Program	3	3

GS Level	16	15	14	13	12	11	9	7
Percentage* of returned sample	2	12	15	24	15	12	10	10
Percentage* of population	1	9	17	28	16	13	10	6

*Percentages for sample do not add to 100 due to rounding.

CHAPTER IV

ANALYSIS OF RESULTS

This chapter will discuss the major results compiled from the 191 questionnaires that were returned. The discussion of these results will also reflect the interviews and other observations made during the research project.

Most of the questionnaire responses have been broken down into results for supervisory engineers and non-supervisory engineers. These two groups have been further subdivided into a total of five groups as follows: Group 1, consisting of 24 individuals with second and third level supervisory responsibility; Group 2, consisting of 39 individuals with first-line (or approximately equal) supervisory responsibility; Group 3, consisting of 41 non-supervisors, 35 GS-13's and 6 GS-14's; Group 4, consisting of 49 non-supervisory GS-11's and 12's; and Group 5, made up of 38 non-supervisory GS-7's and GS-9's.

Table IV gives some additional descriptive data for these five groups. Since most recent graduates enter at the GS-7 or GS-9 levels, the progression from Group 5 to Group 1 can be viewed as the progression from entry into the organization upward to middle management by promotion from one group to the next. Group 3 has been in the organization longer and is older than the next higher group, indicating that the GS-13 level may be a plateau beyond which engineers are not as likely to progress unless they move into management.

Since responses to section II are the basis for computing perceived deficiencies, results of this section will be presented first to facilitate an understanding of the nature of the management job at the Manned Spacecraft Center. The remaining questionnaire results will then be discussed under three headings: Perceived Deficiencies, Career Goals, and Attitudes Towards Management Training.

Relative Importance of Management Abilities

Introduction.- Reasons have already been discussed for including this section of the questionnaire as a basis from which to evaluate the management abilities of engineers. While the results of this section may not necessarily reflect the ideal priorities which should be given these abilities for optimum performance by the organization, it will be argued that they do provide the best available indication of the priorities given these management activities by present participants in the organization. In reviewing individual questionnaires, it was noted that each man's

TABLE IV.- DESCRIPTION OF SUB-GROUPS USED IN ANALYSIS

Group Number	Number	Category	Average Age	Average number of years at MSC
1	24	Second and third level supervisors	40.3	6.0
2	39	First-line supervisors	35.0	4.8
3	41	Non-supervisory, GS-13 or above	39.0	5.0
4	49	Non-supervisory, GS-11 and 12	29.5	3.7
5	38	Non-supervisory, GS-7 and 9	25.2	1.1

responses reflected to some extent the nature of his particular job and supervisors, and the time spent using various abilities. Summary totals for a large sample should then provide a measure of the relative importance of various areas of ability to effective management of the organization, as perceived by members of the organization.

The inclusiveness of the list of abilities was somewhat confirmed by the fact that in only a few cases were responses added to the list by the respondents. Those qualifications added could usually be properly subsumed under one or more of the items already listed.

Evidence has been presented that perceptions of supervisors and subordinates often differ. In this instance, it would be expected that the opinions of supervisors might be a more valid indication of the management job, since presumably they are more familiar with management than are non-supervisors. Accordingly, the results of this section will be broken down into responses given by supervisory and non-supervisory engineers.

Results.- The average scores given each of the 17 items by supervisors, non-supervisors, and the total group are listed in Table V. For a presentation of the average ratings by each of the five groups described above, see Appendix B.

There was little variance between perceptions of non-supervisory engineers and those of supervisors, especially in those abilities which they rated as most important. On only two items did the rank of a particular item vary by more than two between the two groups. Non-supervisors considered "knowledge of and ability to use other parts of the MSC organization" more important than did supervisors, and supervisors considered "ability to handle subordinates' personal and interpersonal problems" more important. Otherwise, there was general agreement between the two groups as to the abilities and knowledge required to be an effective manager at MSC.

"Ability to make correct and timely decisions" was judged to be the most important managerial ability by a significant margin. Next most important, grouped closely, were: "favorable personal traits", "ability to work with higher management", "ability to plan and establish goals", and "ability to motivate subordinates". Surprisingly, "above average technical knowledge" was ranked near the bottom of the list by the total sample and was ranked last by supervisors. A possible explanation for this is that perceptions of the relative importance or resources are influenced by their scarcity. If it is assumed that the MSC organization has an abundance of engineering talent, it is conceivable that this might cause technical knowledge to be perceived as less important. However, even after considering the possible influence of this factor, one cannot

TABLE V.- PERCEIVED RELATIVE IMPORTANCE OF MANAGEMENT ABILITIES

Area of Ability	Total		Supervisors		Non-Supervisors	
	Average Score	Rank	Average Score	Rank	Average Score	Rank
Decision-making	9.2	1	9.3	1	9.2	1
Personal traits	8.8	2	8.8	3	8.8	2
Working with superiors	8.8	3	8.9	2	8.7	3
Planning and establishing goals	8.6	4	8.5	5	8.6	4
Motivating subordinates	8.4	5	8.8	4	8.2	5
Establishing organizational structure	8.0	6	7.9	7	8.0	7
Scheduling work load	8.0	7	8.3	6	7.9	8
Knowledge of MSC organization	7.9	8	7.5	13	8.1	6
Written communications	7.9	9	7.8	10	7.9	9
Working with contractors	7.8	10	7.9	8	7.8	10
Conducting meetings	7.8	11	7.7	11	7.8	11
Coordinating and controlling subordinates	7.6	12	7.5	12	7.7	12
Oral presentations	7.6	13	7.5	14	7.7	13
Handling personal and inter-personal problems	7.6	14	7.9	9	7.4	14
Technical knowledge	7.1	15	6.8	17	7.2	15
Developing subordinates	7.0	16	7.3	16	6.9	16
Reading	7.0	17	7.3	15	6.8	17

eliminate the possibility that in many management jobs at the Manned Spacecraft Center technical excellence is not a necessary qualification for effective performance.

It is also significant that writing, speaking, and reading ability, the communications skills often considered to be both the most important of managerial abilities and the areas in which engineers are most deficient, were ranked only 9th, 13th, and 17th among the 17 items. This indicates that, even if engineers are weak in these communications skills, other areas of management training may be more deserving of emphasis.

The relatively low importance perceived for "ability to aid subordinates' development" may indicate that the needs for management training indicated by this study could at least partially be fulfilled by an increased emphasis on on-the-job development of subordinates by supervisors.

Perceived Deficiencies

Evaluations of Self and Managers.- It has been argued that priorities for management development should be determined by the gap between the amount of proficiency required and the present state of ability. Basing conclusions only on assessment of present ability would ignore the fact that the value of various areas of management ability (and of management training) may vary. Accordingly, the results of sections II, III, and IV of the questionnaire are presented here in terms of the differences between the importance perceived for the various items in sections II and the respondent's assessment of his own ability (section III) or his assessment of his managers' ability (section IV). A summary of these differences is presented in Table VI, and results for the five groups described by Table VI may be found in Appendix B.

The average respondent's evaluation was approximately 10 percent higher than his evaluation of his managers. In analyzing this result, it was reasoned that the average individual probably overestimated his own ability and underestimated (or underrated) his managers' ability. Lacking previous research showing the relationship of reality to such evaluations, it was decided that the actual ability of the average engineer would best be indicated by a point between these two evaluations. The following discussion and conclusions are thus based on the average of these two indications of deficiency in management ability. Since no significant patterns of differences between results for supervisors and those for non-supervisors was found, the total sample results were chosen as the best indication of management training needs.

In three areas, these deficiencies were approximately equal and considerably greater than the deficiencies in the other 14 areas. These were: decision-making ability, ability to plan and establish goals, and

TABLE VI.- SUMMARY OF PERCEIVED DEFICIENCIES

Area of Ability	Perceived Deficiency								
	Total			Supervisors			Non-Supervisors		
	Average	Self	Superiors	Average	Self	Superiors	Average	Self	Superiors
Decision-making	2.3	1.9	2.7	2.4	1.5	3.3	2.3	2.1	2.5
Established goals	2.3	1.8	2.8	1.95	1.0	2.9	2.4	2.1	2.7
Motivating	2.25	1.5	3.0	2.4	1.2	3.6	2.2	1.7	2.7
Organizing	1.8	1.2	2.4	1.6	.5	2.7	1.9	1.6	2.2
Working with supervisors	1.75	1.9	1.6	1.75	1.7	1.8	1.7	2.0	1.4
Scheduling work	1.55	1.0	2.1	1.7	.8	2.6	1.55	1.2	1.9
Personnel problems	1.5	.8	2.2	1.55	.7	2.4	1.4	.8	2.0
Personal traits	1.4	1.2	1.6	1.34	1.1	1.6	1.4	1.3	1.5
Conducting meetings	1.25	1.4	1.1	1.0	.6	1.4	1.35	1.7	1.0
Coordinating and controlling	1.2	.7	1.7	.8	.1	1.5	1.45	1.0	1.9
Developing subordinates	.95	.3	1.6	1.0	.1	1.9	1.0	.5	1.5
Oral presentations	.85	1.1	.6	.5	.7	.3	1.0	1.3	.7
Written communications	.8	.6	1.0	.5	.2	.8	.85	.7	1.0
MSC organization knowledge	.75	.8	.7	.35	.2	.5	1.2	1.7	.8
Reading	.7	.7	---	.7	.7	---	.6	.6	---
Working with contractors	.55	.5	.6	.45	.2	.7	.65	.7	.6
Technical knowledge	.05	0.0	.1	(.45)	(.5)	(.4)	.25	.2	.3

ability to motivate subordinates. The average deficiency perceived in these areas was 2.3 on the 10 point scale. This figure has more meaning when expressed as a deficiency of 25 percent, 27 percent, and 27 percent, respectively, of the amount of ability perceived as required for effective management. In addition to these questionnaire results, interviews and conversations with engineers and comments received on the subjective areas of the questionnaire can be cited as evidence that engineer-making, planning, and motivating. The second and third of these three areas are subjects in which engineers receive relatively little formal education, but at first glance it might seem that engineers should be strong in decision-making ability because of the problem-solving orientation of much of their undergraduate work. However, as has been implied by literature cited in Chapter II, an orientation toward the detailed and exact decision-making process used in many engineering problems may in fact be a hindrance when dealing with managerial problems in which many variables are not subject to quantification and time limitations often preclude an exact and detailed analysis of the problem. That engineers feel a difficulty in dealing with human problems and subjective considerations rather than technical problems is further evidenced by the fact that almost no deficiency was perceived in technical knowledge.

Following these three areas in need for training is a second group of four with an average deficiency of from 1.5 to 1.8 and the percentage described above ranging from 19 percent to 22 percent. In this group were: ability to establish an effective organizational structure, working with higher management, scheduling the work load, and understanding and dealing with subordinates' personal and interpersonal problems. It is difficult to cite an area of knowledge or type of training that can focus specifically on the second of these four areas, working with higher management. Subjective questionnaire responses and other observations have indicated that this felt deficiency may be the result of some negative feelings toward higher management and a need for better communication vertically through the organization. Thus, the feeling of an inability to work with higher management may have been perceived as due to a deficiency on the part of higher management, and may indicate a need for a better understanding of human relations by higher management. The other three areas in this second group are again topics in which most engineers receive relatively little formal training and indicate a need for greater knowledge of organization theory, human behavior, and planning theory and methods.

In all these first seven areas, and in general for the entire list, there was little difference between the average perceptions of the supervisory engineer and the non-supervisory engineer. In only three areas was the difference between the average deficiencies perceived by these two groups greater than 0.5. The non-supervisory engineers saw "knowledge of and ability to use other parts of the MSC organization", "above-

average technical knowledge", and "ability to coordinate and control subordinates" as larger deficiencies than did the supervisors.

The communications skills (oral presentations, reading, and writing) ranked 12th, 13th, and 15th in deficiencies. This does not mean that teaching these skills is not necessary or that engineers are proficient in these areas. Examining results of self-evaluations alone reveals in fact that reading, giving oral presentations, and a related skill, conducting meetings and conferences, and the three areas on this list in which engineers feel they are least proficient. However, placing this in perspective by looking also at the nature of the management job and the value and importance perceived for various areas of ability, discloses that other activities may be more important to the effective management of the organization and thus deserve more emphasis in training than they have received. The 9th and 12th rankings of "ability to conduct meetings and conferences", and "ability to give good oral presentations", and the average deficiencies perceived of 1.25 and .85 (16 percent and 11 percent) indicate that, among the communications skills, improving the engineer's ability to speak before a group deserves primary emphasis.

The only area in which no significant deficiency was perceived was technical knowledge. The supervisors and managers indicated, in fact, that they and their managers had more than enough technical knowledge to perform effectively as managers. This result may have implications both for training and for the process and criteria used in selecting managers. Perhaps the fact that managers are deficient in some of the other areas discussed above is partially the result of placing too much emphasis on technical ability in their selection.

Educational Subjects Perceived as Needed.- The final section of the questionnaire provided another measure of deficiency in management ability, asking the respondent to indicate educational subject areas in which he needs further training. Including fill-in categories for technical subjects, 40 subjects were listed. Table VII shows results for 16 courses that were requested by more than 25 percent of the sample. Results for all 40 courses selected by various GS-levels may be found in Appendix B.

In general, there was a good correlation between these results and the deficiencies indicated by the first part of the questionnaire. Exceptions were the communications skills, which ranked 2nd, 4th, and 7th on this list of 40 subjects, but (according to results presented in the previous section of this report) were not among the areas with the greatest deficiencies of ability. Several factors help to explain what would seem at first glance to be an inconsistency in the respondents' perceptions. Most important, public speaking, reading improvement, and written communications are generally recognized as areas in which education and training can make significant improvements. These courses can be directly

TABLE VII.- SUBJECTS REQUESTED BY

25 PERCENT OF RESPONDENTS

Rank	Name of Subject	Percent
1	Problem solving and decision-making	54
2	Public speaking	49
3	Planning and goal setting	41
4	Reading improvement	39
5	Elements of supervision	39
6	Principles of leadership	36
7	Management of research and development	36
8	Written communication	36
9	Individual and group motivation	34
10	Principles of organization	34
11	Creative thinking	31
12	Computer applications	30
13	Human relations	27
14	Human behavior in organizations	26
15	Conference leadership	26
16	Engineering specialties	26

related to deficiencies in ability, and their value has been proven and is well known. On the other hand, it is difficult to directly relate any specific bodies of knowledge to some of the other areas of management ability, and the value of some of the other courses listed has not been demonstrated as well as that of these three subjects. A second influence on these results is the fact that these courses are now a major part of the management training effort and have been taken by many engineers.

The perceived needs for a course in making oral presentations by 49 percent of the sample and a course in conducting meetings and conferences by 26 percent are further support for the statement made above that training in oral communication should have first priority among communications skills. These figures and those for reading improvement (39 percent) and written communications (36 percent), and the fact that these courses have proven value, would seem to justify continuing to make these courses a significant part of the management development curriculum.

Results for other subject areas provide support for statements which have been made about priorities for management training. It was stated in the previous section that the largest deficiencies in ability were in the areas of decision making, planning and establishing goals, and motivating. A course in "Problem Solving and Decision-Making" was the most popular of the 40 subjects, being requested by 54 percent of the respondents. "Planning and Goal Setting" was selected by 41 percent, ranking it 3rd; and "Individual and Group Motivation" ranked 9th, selected by 34 percent.

"Ability to establish effective organizational structure", the fourth largest deficiency indicated by the previous section, could be related to a course in "Principles of Organization", selected by 34 percent of the respondents, and courses in "Human Relations" and "Human Behavior in Organizations" could be related to the perceived deficiencies in "ability to understand and deal with personal and interpersonal problems of subordinates" and "ability to work with higher management".

Looking at other courses and areas of perceived deficiency discloses some courses which are general in nature and would include content relating to several areas of ability and some areas of managerial ability to which no single subjects can be related. Responses for some courses listed, such as "Elements of Supervision", serve as further indications of engineers' need for and interest in management training in general.

The fill-in areas for technical courses could be related to the manager's need for technical competence; but, due to the fact that these items required a written response as opposed to a check for the other items, results for these questions probably do not provide an accurate indication of engineers' needs for further technical education as compared to management education. The 26 percent who entered courses in

the blanks for "Engineering Specialties" were primarily those who indicated elsewhere in the questionnaire that they were not interested in a management career. The most common request in this area was for a good general engineering refresher course.

There was considerable evidence for the need for a general course in research and development management. Thirty-six percent of the respondents indicated a need for this subject, but the percentage was much higher than this for higher levels. A number of comments entered in the subjective areas of the questionnaire also hinted at the need to educate engineer-managers in some of the unique factors which may be involved in supervising engineers and scientists.

Career Goals of Engineers

Introduction.- This section will present results of section V of the questionnaire and other results with implications for engineers' career goals. The preconception that required research in this area was that engineers and scientists often have primarily technical goals and resent having to take time away from their technical efforts for managerial duties. In studying the requirements for a management development program, then, one question to be answered was whether such a program need attempt to interest more engineers in management careers. The evidence presented here indicates that such a problem does not exist; it shows that the number of engineers interested in management careers is more than enough to fill the number of management positions, so that the problem is one of selecting the right individuals and providing for them the proper training.

Initial Attitudes.- Responses concerning the engineer's attitude toward management when first coming to the organization are summarized in Table VIII. These figures indicate that most engineering graduates are interested in eventually moving into management; many see their engineering degree as a means of advancing into technical management. As shown by Table VIII, 63 percent of the 191 engineers surveyed indicated a definite interest in a management career, and another 20 percent indicated at least an open mind. A relatively small percentage felt they had firmly decided upon an engineering career when they first came to the Manned Spacecraft Center.

Present Attitudes.- When asked their present choice between the two types of jobs, 80 percent of the respondents indicated that, in general, they would prefer a "technical management job" over an "engineering job". (For a breakdown of responses to this question, see Appendix A.) When compared to the above results, this does not seem to represent any significant change in attitudes. Answers to the two intervening subjective questions indicated that one reason for any change in attitudes which

TABLE VIII.- INITIAL CAREER ATTITUDES

Percent	Attitude
12	Pretty sure wanted career in engineering; did not want to supervise unless necessary to advance.
20	Primarily interested in engineering; hadn't given management much thought.
37	Some desire to eventually enter management career.
26	Management primary goal.

does take place is the recognition of organizational factors such as salary and promotion opportunities for the two careers.

One reason for the large percentage indicating a preference for management is the fact that "technical" management was specified. There is some evidence that a significant number of engineers who responded that technical management was their choice were still motivated primarily by technical reasons. A few qualified their answers by saying they would not want a management career if it meant being too far removed from engineering work.

Reasons for Career Preference.- In order to gain some understanding of the reasons behind the above results, the respondents were asked to indicate all reasons (from a list of 12) that were applicable to their preference, then to indicate the most important of these reasons. Results for the second of these two questions are given by Table IX. More than 50 percent of those indicating a preference for technical management listed either "salary and promotion opportunities" (26 percent) or "being able to take part in planning and major decisions" (25 percent) as the primary reason. The third most important reason was "my own personality and capabilities" (20 percent). Two factors dominated the reasons given by those preferring an engineering career: "my own personality and capabilities" (34 percent), and "the creative aspects of engineering" (29 percent).

For a further indication of the importance of salary and promotion opportunities, the respondents were then asked their career preference, assuming that salary and advancement were equal for the two careers. In this case, 68 percent indicated a preference for technical management and 32 percent engineering. The 12 percent change was smaller than might have been expected but large enough to indicate that salary is an important influence on these engineers' career preferences. It is also significant that 26 percent of those indicating a preference for technical management on the first question gave "salary and promotion opportunities" as the most important reason, but that none of those preferring an engineering career gave this as the most important reason.

Although there are several suggestions that the 80 percent who indicated a preference for management include some who are not highly motivated toward management and some who are motivated by factors other than enthusiasm for the work itself, the evidence that is available indicates that there is a significantly large number of engineers who are thus motivated toward management work.

Career Patterns and Perceptions of Ability.- One finding which resulted indirectly from analysis of the first four sections of the questionnaire has some implications for an understanding of the engineer's

TABLE IX.- REASONS GIVEN AS MOST IMPORTANT FOR CAREER PREFERENCE INDICATED

Management Preference, Percent*	Factor	Engineering Preference, Percent*
20	My own personality and capabilities	34
1	Creative aspects of engineering work	29
25	Being able to take part in planning and major decisions	3
26	Salary and promotion opportunities	0
12	Opportunities for professional growth and recognition	10
11	The general nature of management work	5
12	The additional responsibilities of management	0
1	The status of my technical skills and knowledge	5
0	The general nature of engineering work	5
1	The people I would be working with	3
1	My educational background	0
1	The exactness and technical details of engineering work	5
6	Other	5

*Percentages do not add to 100 due to the fact that some respondents checked more than one factor as "most important".

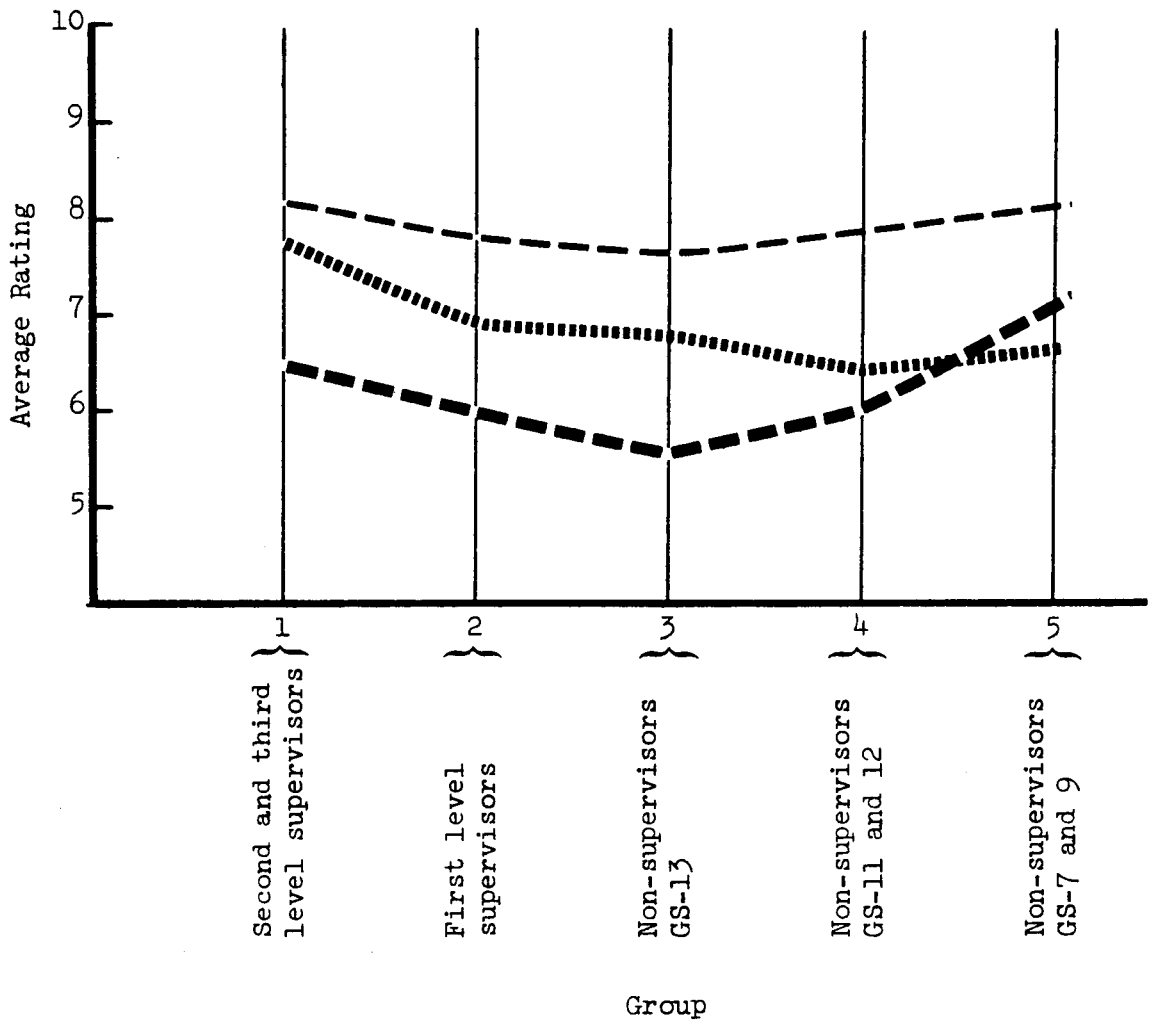
career attitudes. An average score for all 17 listed items of managerial ability provides a composite score of the average engineer's opinion of his own ability as a manager and his manager's ability. When graphed as averages of responses from five groups, as in figure 1, these figures represent a pattern of attitudes which may have implications for management training and development.

As shown by this graph, the average engineer's opinion of his own managerial ability gradually increases from the level of GS-7 and GS-9 up to middle management. For all groups except the youngest and newest to the organization, the self-evaluation of managerial ability is greater than the opinion of one's manager. The general opinion of the ability of one's manager declines from entry into the organization until the level of GS-13 is reached at which point it is lowest. It then increases for individuals who are themselves supervisors and managers, but the gap remains large between the two evaluations. These results are subject to many interpretations, but among other things, they would seem to suggest two things. First, the gradual decline of opinion of managers' ability throughout the non-supervisory levels suggests a need for a greater understanding of the management job and its requirements by lower levels. It has already been pointed out that few management courses are available to non-supervisors. Second, the relatively low opinion of managers' ability at all levels is an indication of the need for improving managers' performance, in general, and may also point up a need for better communication and understanding between supervisory and subordinates.

Attitudes Toward Management Training

This section of the questionnaire represents an effort to determine the engineer's opinion of the value and role of management training. Detailed results for the questions used may be found in Appendix A. Three questions were used to attempt to measure opinions of the role of inherent traits, actual experience, and education and training in determining management ability. From the questionnaire results it can be concluded that these engineers feel that on-the-job experience and management education play a much greater part than inherent traits in determining managerial capability. They indicated a strong belief in the potential value of management training, as 82 percent answered either that it "is necessary and can be of great value" (40 percent) or "can do much to improve deficiencies" (42 percent). Only 3 percent answered that management education and training "is of little value compared to inherent abilities and actual experience".

Respondents were then asked to indicate what percentage of any time spent furthering their education they would like to spend on management training with the remainder to be used for technical training. Results



LEGEND:

— — IDEAL (Questionnaire Section II)

▪▪▪▪▪▪▪ SELF-PERCEPTION (Questionnaire Section III)

▬ ▬ PERCEPTION OF MANAGERS (Questionnaire Section IV)

Figure 1.- Composite Evaluations by Sub-Groups: Averages of Ratings for 17 Abilities for Sections II, III, and IV of the Questionnaire.

for this question were separated into two groups: those who indicated a preference for an engineering career and those who preferred technical management. The overall average was 52 percent, but for the management group the average response was 60 percent. It is possible that misreading the question as "what percentage of your time" rather than "percentage of this education time" may have caused this figure to be too low, but the results would still seem to indicate that even those who want management careers feel that a significant portion of their continuing education should be technical. This is not inconsistent with the low deficiency perceived in technical knowledge if it is assumed that this amount of continuing technical education is needed just to keep abreast of technology. The average response for the individual who prefers an engineering career was that 31 percent of his education time should be spent on management training with the remainder spent on technical.

CHAPTER V

SUMMARY AND CONCLUSIONS

General: Engineers' Need for Management Training

At the Manned Spacecraft Center and in many other organizations, a need exists for individuals with technical training and experience to fill management positions, especially those responsible for technical effort. Thus it becomes necessary to assess the ability of engineers and other technical people to perform as managers and to then identify the requirements for education and development to fill the gaps that may exist.

On the basis of the research done in this study, it can be concluded that a definite need exists for improving the managerial skills and knowledge of engineers who are managers or who are to become managers. If for no other reason, this need exists because of the fact that the engineers themselves feel a lack of ability to perform effectively as managers. This is evidenced by questionnaire results which show their composite evaluations of their own ability to be about 15 percent below their perceptions of what it should be and their perceptions of their managers' abilities as 20 percent below this ideal. The magnitude of the real deficiencies in ability that exist is probably not subject to exact measurement, but these results imply a real need for improving the knowledge and ability of engineers who are potential managers, in addition to the need for improving their confidence as managers by reducing their own perceptions of shortcomings as managers.

Although examining the typical engineering curricula discloses that many subjects of possible value to managers are not included, it cannot be said on the basis of this study that engineers as a group are any more or less deficient as managers than persons of other educational backgrounds. This question would require a similar study including other groups for comparison. However, such comparisons would seem to be of secondary importance even if they were available as long as it can be concluded that engineers are deficient as managers and that they need supplementary education and development. This study shown that, for the average engineer, such requirements do exist.

Career Goals

The preconception that most research and development engineers have primarily technical goals and are not motivated toward management careers was shown to be incorrect. The study revealed that many engineers desire

and are seeking the additional responsibility and wider scope of duties that they feel are offered by management jobs. The tendency to resent having time taken away from technical activities for administrative duties was not noted among the engineers studied in this project.

Results show that a large majority of engineers are more interested in a career in technical management than in spending their career in engineering work. Many have made this choice because of recognition of the fact that their salary and advancement goals cannot be satisfied by remaining in purely technical work, and others would not want a management job that would prevent them from spending some time in engineering duties. It must be concluded, however, that a large number of engineers are motivated toward management by the nature of the work itself, seeking the additional responsibility. Because it is difficult to isolate real motives for indicating a preference for management, a precise statement cannot be made about the percentage of engineers who have this favorable motivation toward managing, but all indications are that it is certainly large enough to fill the available management positions.

Thus there is not significant need to change engineers' attitudes toward management careers, and a program for management development does not have the initial task of providing this motivation. This study indicates, in fact, that possibly a more significant problem is that of providing the type of work and rewards necessary to motivate a sufficient number of engineers to devote their careers to the technical excellence that is necessary to the effectiveness of an organization such as the Manned Spacecraft Center.

The implications of these results, then, for a management development program for engineers, are that such a program should concentrate on selecting engineers who are motivated toward management work and are most qualified to become managers and should then provide these engineers with the education, training, and guidance necessary for their development into effective managers.

Priorities for Management Training

What then, should be the components of a program of management development for engineers, and what relative emphasis should be given to various management skills and knowledge in such a program? Certainly there is a need for further research in this area before the tentative conclusions which can be drawn from this study can be verified, but these conclusions should be the most objective basis now available for answering these questions.

The first conclusion which can be drawn is that engineers feel a lack of ability to make the decisions required of a manager. The study

was consistent in indicating this as the first priority for management development; it was the largest deficiency perceived in the evaluations made and was also the subject area perceived as needed by the largest number of engineers, 54 percent of the sample. Difficulty is evidently encountered by engineers in making decisions which involve subjective considerations; the respondents' perception of little deficiency in technical knowledge indicates that it is not technical decisions that are difficult for engineers but those which involve human factors and require judgment and sometimes a certain amount of courage. Courses which teach a decision-making procedure and methods for reducing some of the subjectivity of managerial decisions can help decrease the deficiency perceived in this area. Improvement should also be made by giving young engineers more opportunities to participate in and observe management decisions and more assignments that will challenge decision-making ability.

A second topic in which the study indicates training is needed in planning. Felt deficiencies in "planning and establishing goals" and "planning and scheduling the work load" and the perceived need of a course in "Planning and Goal-Setting" by 41 percent of the questionnaire respondents are evidence that high priority should be given to courses teaching planning theory and methods and that more emphasis should be placed on working with a plan or schedule, toward known objectives, while on the job.

The deficiencies perceived in "motivating subordinates", "working with higher management", and "understanding and dealing with personal and interpersonal problems of subordinates" and results for courses in motivation, human relations, and "Human Behavior in Organizations" indicate a need for including more of a content of these specific courses and the behavioral sciences in general in management training for engineers. Closely related to these subjects is the deficiency perceived in "ability to establish effective organizational structure for subordinates" and the felt need for a course in "Principles of Organization".

A final area which deserves strong emphasis is that of communications. Results of this study were consistent with previous studies in showing that engineers feel that they are weak in speaking to groups. Although the questionnaire evaluations indicated somewhat less deficiency in this than the subjects mentioned above, a course in "making oral presentations" was requested by 49 percent of these engineers. Courses in reading improvement and written communications were perceived as needed by 39 percent and 34 percent of the respondents. The popularity of these courses and the indications that deficiencies in these subjects are considerable (though not the largest), justify making communications skills a significant part of a management development program for engineers.

The evidence of this study shows that, for most management positions at the Manned Spacecraft Center, outstanding technical ability is not

required to perform well as a manager. This is not to say that some time will not be required for some managers to remain technologically current. But for most managers, management training should have priority over technical training, and managerial abilities should be considered more important than technical ability in selecting managers.

Results of this research project indicate that there is a general need for an increased emphasis on both formal educational programs and informal on-the-job development of managerial ability in engineers. The areas of primary emphasis in such programs, as indicated in this study, have been summarized above. Questionnaire results for a number of other courses not discussed here are available in Appendix A and should be considered in designing a management training program.

CHAPTER VI

RECOMMENDATIONS

The results of this research project have been discusses and summarized, and some conclusions have been drawn. It now becomes necessary to state these results in the form of recommendations to the organization studied. These recommendations are based on what has been learned about the following questions: Who should be included in management development and how should they be selected? What methods should be used to develop these people into managers? In what specific areas is training needed, and what guidelines should be used in designing a program to meet these needs? What further evaluation or feedback is needed to ensure that management development will best accomplish its purpose?

The recommendations of this study are summarized below under four headings corresponding to these four broad questions.

Selection of Potential Managers

An attempt should be made to identify early in their careers those engineers who are motivated toward management work, and their potential as managers should be evaluated with primary emphasis on their qualifications as managers rather than their technical performance. (This is not to say that technical qualifications may not be important but that they should not be the primary consideration.) For engineers who meet these qualifications, management development should begin before a supervisory position is reached. Also, courses in communications skills, human relations, and some basic exposure to the role of management should be available to all engineers. On-the-job development, which will be discussed below, should be used both for development purposes and to assist the supervisor in evaluating his subordinates' potential as managers and selecting individuals to participate in formal management development programs.

Scope of Management Development

More emphasis should be placed on conscious development of the engineer by his supervisor while on the job. Significant improvements could be made by offering the engineer more exposure to managerial problems and more challenging assignments while he is engaged in productive work. This method of development can be applied even when work loads prevent taking time away from the job for formal education programs. This should be encouraged by letting managers know they will be evaluated in terms of their ability to develop replacements.

In formal management training, a more comprehensive effort should be made to ensure that individuals receive the training that is needed. On the basis of a preliminary evaluation of the engineer's strengths and weakness, a curriculum should be outlined for each individual. Also, an effort should be made to ensure that, through these individual plans, the manpower needs of various organizational components will be met.

Structure and Content of Management Education

When budgetary restrictions are encountered, decisions about priorities for the content of formal management training should be based on the results of this study. These priorities, summarized in the previous chapter, should be the best basis presently available for determining the content of management education. It is also recommended that effort be made to make the material presented in these courses more applicable to the activities and personnel of the Manned Spacecraft Center. A final recommendation is that consideration be given to using a different format than the one or two week, 8 hour day courses presently used. If local instructors could be used or other economic considerations permitted, material could be distributed over a longer period of time. This would allow the individual to keep up with the work load while participating, thus allowing the involvement in management training of many engineers who now cannot find time to participate. It would also permit the assignment of more "homework" or outside reading and allow the participant more time to evaluate and reflect upon the material presented than is possible with a format which masses 40 hours of instruction into one week.

Feedback and Future Studies

It is recommended that more effective feedback procedure be used to assist in evaluating management training. The method used should be as specific as possible, allowing decisions to be made about particular components of courses taught or specific aspects of the method in which they are presented.

It is also felt that there is a need for further research into the general questions attacked by this study. A follow-up study using methodology similar to that of this study could be of value in determining whether engineers' perceptions of their managerial ability or their evaluations of their managers' abilities have changed after receiving training in the areas in which they now feel deficient. Future studies should strive for objectivity, possibly using the testing method discussed in Chapter III. It is hoped that this study will contribute as background for future studies to be made in this field.

A SELECTED BIBLIOGRAPHY

American Society for Engineering Education. "Education in Industry." Journal of Engineering Education, LV (May, 1965), pp. 254-256.

Bellows, Roger, Thomas Q. Gilson, and George S. Odiorne. Executive Skills: Their Dynamics and Development. Englewood Cliffs, N.J.: Prentice-Hall, 1962.

Bittel, Lester R., and Robert L. Craig, eds. Training and Development Handbook. New York: McGraw-Hill Book Company, 1967.

Constas, Perry A. "Engineering Education and the Engineer's Self-Image." Personnel Journal, XLV (March, 1966), pp. 153-158.

Corson, John J., and R. Shade Paul. Men Near the Top. Baltimore: John Hopkins Press, 1966.

Flippo, Edwin B. Principles of Personnel Management. New York: McGraw-Hill Book Company, 1966.

Given, William B., Jr. "The Engineer Goes Into Management." Harvard Business Review, XXXIII (January-February, 1955), pp. 43-52.

Harrell, Thomas W. Managers' Performance and Personality. Cincinnati: Southwestern Publishing Company, 1961.

Hicks, Tyler G. Successful Engineering Management. New York: McGraw-Hill Book Company, 1966.

Howland, Warren, William K. Lebold, and Robert Perucci. "The Engineer in Industry and Government." Journal of Engineering Education, LXVI (March, 1966), pp. 237-274.

Kahn, Robert L., and Daniel Katz. The Social Psychology of Organizations. New York: John Wiley and Sons, Inc., 1966.

Katz, Robert L. "Skills of an Effective Administrator." Harvard Business Review, XXXIII (January-February, 1955), pp. 33-42.

Krugman, Herbert E. "What Kind of Managers Will Scientists Make?" Management Review, XLVII (May, 1958), pp. 22-28.

Landis, Fred. Engineering Obsolescence and Continuing Education. Report to the Office of University Affairs, National Aeronautics and Space Administration, July, 1967. New York: New York University, 1967.

Odiorne, George S. "Making Managers Out of Engineers." Personnel, XXXIII (November, 1956), pp. 259-266.

Sayles, Leonard R. Managerial Behavior: Administration in Complex Organizations. New York: McGraw-Hill Book Company, 1964.

Stolz, Robert K. "Executive Development - New Perspective." Harvard Business Review, XLIV (May-June, 1966), pp. 133-143.

APPENDIX A:

QUESTIONNAIRE AND SUMMARY RESULTS

INTRODUCTION AND GENERAL INSTRUCTIONS

This questionnaire is part of a study of the management training and development needs of engineers. The results of this study and the information requested by this questionnaire will be used to help in selecting and structuring training courses to be offered, and in designing programs for developing and improving management ability in technical personnel.

In addition to assisting in developing programs that may aid in your career development, it is felt that the questionnaire may be interesting to you in that it will stimulate thinking about your own career plans and goals. For these reasons you are asked to give careful thought to the questions and answer each question as honestly and accurately as possible. Under no conditions will individual responses be made available to anyone but the researcher, who will be leaving MSC to complete requirements for a graduate degree upon completion of the study.

This questionnaire is designed for both supervisory and non-supervisory technical people, and all questions are applicable regardless of your present position in the organization or your attitude toward a management career. Your responses are of interest and will be of help even if you personally have little interest in a management career.

In completing the questionnaire, you should think of the words "manager" and "management" as referring to technical management and including all levels of management, from first line supervisor through top management. The questionnaire is concerned with management in general, but your answers will necessarily be based on the type of management and levels of management with which you are familiar.

Please fill out the questionnaire completely and please be as objective as possible. Return to code BP3 by March 29. Your help is greatly appreciated.

I. BACKGROUND INFORMATION

1. Your present mailing code if different from above _____

2. Number of years you have been a Civil Service employee _____

3. Grade level at which you entered the Civil Service: GS-_____

4. How long have you been at MSC? 4.0 years (6.2/4.8/4.9/3.7/1.2)*

5. Present grade level: GS-12.3

6. Your age 33.2 (40.3/35.0/39.0/29.5/25.3)

7. Education: (a) Highest level of education completed BS-163; MS--24; PhD--4

   (b) List college degrees received:

Degree	Major Field	Year Received
Bachelor Degree	Engineering - 142	
	Physics or Math - 44	
	Chemistry - 5	

8. Experience: Breifly summarize your work experience with respect to type of work.

   ( ) Primarily Engineering

   ( ) Other (specify) _____

9. Present job: State briefly the type of work you do in your present job.

   _____

   _____

10. Supervisory experience:

    (a) Number of years as a supervisor or manager at MSC _____

    (b) Total number of years as a supervisor or manager (If different from above) _____

    (c) Briefly describe any experience you have had supervising or managing other than at MSC:

    _____

    _____

    _____

*Figures in parentheses are subtotals for groups 1 - 5.

11. Present supervisory responsibility:

(a) Indicate the level of supervisision that best describes your present job:

(4) Division Chief

(20) Branch Chief

(39) Section Head

( ) No supervisory or management responsibility

(128)

( ) Other (describe): _____

(b) Total number of employees you are responsible for (approx.)___

(c) Number of employees reporting directly to you _____

II. Below is a list of areas of ability that are normally associated with management activity. You are asked to indicate your assessment of the importance of each item as a qualification for being a good manager at MSC. You should give your opinion of what is required to be an effective manager, basing your answer on either your experience as a manager, your observation of management, or both.

Indicate your opinion of the importance of each item by circling any number between 1 and 10 for each item, a response of 10 indicating maximum importance. The meanings designated below for 1, 5, and 10 are to serve as guidelines. You may add items to the list if you feel that important abilities have not been listed.

10 = extremely important; a necessary qualification for effective management

5 = of average importance

1 = of relatively little value or importance

1.	Above-average technical knowledge	7.1
2.	Knowledge of MSC organization and ability to work with other parts of the organization	7.9
3.	Good written communications	7.9
4.	Ability to give good oral presentations	7.6
5.	Ability to read rapidly with good comprehension	7.0
6.	Ability to conduct meetings and conferences	7.8
7.	Ability to make correct and timely decisions	9.2
8.	Ability to plan and establish goals for organizational unit	8.6
9.	Ability to establish effective organizational structure for subordinates	8.0
10.	Ability to plan and schedule work	8.0
11.	Ability to motivate subordinates toward goals	8.4
12.	Ability to understand and deal with both individual and interpersonal problems of subordinates	7.6

13.	Ability to coordinate and control subordinates' work	7.6
14.	Ability to aid subordinates' self-development	7.0
15.	Ability to be effective in talking to and working with higher management	8.8
16.	Ability to be effective in talking to and working with outside contractors	7.8
17.	Favorable personal traits: self-confidence, motivation to achieve, enthusiasm, dependability, initiative	8.8
18.	Other (write in) _____	

III. In this section you are asked to make a self-examination of your management knowledge or capabilities. For the same list of abilities used in the previous section, you are asked to indicate what you think is your proficiency in this area. For some of the items, you may not have had much experience in using this ability; if this is the case, base your answer on the knowledge you have in this area, and how well you think you could perform. As before, you may mark any number from 1 to 10. The meanings given for 1, 5, and 10 should serve as guidelines.

10 = extensive knowledge and ability

5 = average proficiency

1 = relatively little ability or knowledge

1.	Above-average technical knowledge	7.1
2.	Knowledge of MSC organization and ability to work with other parts of the organization	6.7
3.	Good written communications	7.3
4.	Ability to give good oral presentations	6.5
5.	Ability to read rapidly with good comprehension	6.3
6.	Ability to conduct meetings and conferences	6.4
7.	Ability to make correct and timely decisions	7.3
8.	Ability to plan and establish goals for organizational unit	6.8
9.	Ability to establish effective organizational structure for subordinates	6.8
10.	Ability to plan and schedule work load	7.0
11.	Ability to motivate subordinates toward goals	6.9
12.	Ability to understand and deal with both individual and interpersonal problems of subordinates	6.8
13.	Ability to coordinate and control subordinates' work	6.9
14.	Ability to aid subordinates' self-development	6.7

15. Ability to be effective in talking to and working with higher management 6.9

16. Ability to be effective in talking to and working with outside contractors 7.3

17. Favorable personal traits: self-confidence, motivation to achieve, enthusiasm, dependability, initiative 7.6

18. Other (write in) _____

_____

IV. Consider now your experience with and knowledge of supervisors and managers you have worked for or worked with at MSC (those of which you have direct knowledge). You are asked to indicate your opinion of the extent to which these managers in general posses the abilities listed.

10 = extensive knowledge and ability

5 = average proficiency

1 = relatively little ability or knowledge

1.	Above-average technical knowledge	7.0
2.	Knowledge of MSC organization and ability to work with other parts of the organization	7.2
3.	Good written communications	6.9
4.	Ability to give good oral presentations	7.0
5.	Ability to read rapidly with good comprehension	
6.	Ability to conduct meetings and conferences	6.7
7.	Ability to make correct and timely decisions	6.5
8.	Ability to plan and establish goals for organizational unit	5.8
9.	Ability to establish effective organizational structure for subordinates	5.6
10.	Ability to plan and schedule work load	5.9
11.	Ability to motivate subordinates toward goals	5.4
12.	Ability to understand and deal with both individual and interpersonal problems of subordinates	5.4
13.	Ability to coordinate and control subordinates' work	5.9
14.	Ability to aid subordinates' self-development	5.4
15.	Ability to be effective in talking to and working with higher management	7.2

16. Ability to be effective in talking to and working with outside contractors 7.2

17. Favorable personal traits: self-confidence, motivation to achieve, enthusiasm, dependability, initiative 7.2

18. Other (write in) _____

_____

V. This section contains questions relating to your attitudes toward management work and your career plans with respect to management.

1. What was your attitude toward a management career when you first came to MSC? (Select the response that best represents what your feelings were.)

(20%)(38) 1. I was primarily interested in an engineering career, and hadn't really given management much thought. (3/6/4/18/7)

(37%)(71) 2. I had some desire to eventually end up in a management job. (10/15/14/22/10)

(12%)(23) 3. I was pretty sure that I wanted to stay in engineering and did not want to get into a supervisory position unless I had to in order to continue to advance myself. (0/1/10/10/2)

(26%)(49) 4. My primary goal was to get into management; the shorter time I was to spend in pure engineering work, the better. (11/13/10/8/7)

(5%)(10) 5. Other (write in) _____

2. What is your present attitude toward supervisory work and a management career? (Briefly summarize your present career plans and feelings toward management work.)

3. If your attitude toward a management career has changed significantly since you came to MSC, at what point in time and why did this change occur?

4. If you were given a choice between a job consisting primarily of non-supervisory engineering responsibilities and another job that involved supervising engineers, which job (in general) would you prefer?

(20%)(38) The engineering job (0/2/9/14/12)

(80%)(153) The technical management job (24/37/31/35/26)
(% = 100/95/78/72/68)

5. You have indicated above a preference for either non-supervisory engineering or management of technical people. In the list below, you are asked to check all factors that are significant reasons for your preference.

(153) Tech M	(38) Engr.			
85%	10%	( )	1.	Salary and promotion opportunities
75%	84%	( )	2.	My own personality and capabilities
29%	68%	( )	3.	My educational background
68%	15%	( )	4.	The additional responsibilities of management.
3%	34%	( )	5.	The exactness and technical details of engineering work
49%	37%	( )	6.	Opportunities for growth and recognition within my profession
25%	24%	( )	7.	The people I would be working with
80%	13%	( )	8.	Being able to take part in planning and major decisions
18%	45%	( )	9.	The status of my technical skills and knowledge
57%	26%	( )	10.	The general nature of management work
3%	50%	( )	11.	The general nature of engineering work
3%	76%	( )	12.	The creative aspects of engineering work
10%	8%	( )	13.	Other (specify) _____

6. Which of the above factors was (or would be) the most important consideration? _____

	(153) Management	(34) Engineering
1.	26%	0%
2.	20%	34%
3.	1%	0%
4.	12%	0%
5.	1%	0%
6.	12%	10%
7.	1%	3%
8.	25%	3%
9.	1%	5%

	Management	Engineering
10.	11%	5%
11.	0%	5%
12.	1%	29%
13.	6%	5%

7. If you were given the same choice between a non-supervisory engineering job and another job supervising or managing technical work, and <u>if salary, promotion opportunities, and working conditions were equal for both</u>, which would you choose?

(32%)(61) The engineering job (0/7/18/20/16)

(68%)(130) The technical management job (24/32/22/29/22)

VI. Questions in this section are designed for you to express your attitudes about management training in general and your feelings about present programs.

1. I feel that Management ability is....a matter of inherent personality traits that training can do relatively little to improve. (Choose one)

(4%)	(8)	mostly	(1/2/0/3/2)
(26%)	(50)	to a large extent	(10/8/13/9/10)
(55%)	(103)	partially	(9/20/20/30/24)
(15%)	(28)	very little	(4/9/6/7/2)

2. I feel improvement in management ability is....the result of experience in handling actual management problems. (Choose one)

(27)	mostly	(4/6/6/4/7)
(110)	to a large extent	(12/18/24/33/23)
(52)	partially	(8/15/10/11/8)
(2)	very little	(0/0/1/1/0)

3. In improving management ability, I feel that management education and training....(check the response that best represents your opinion)

(77)	is necessary and can be of great value	(9/18/15/20/15)
(79)	can do much to improve deficiencies	(9/13/17/21/19)
(25)	can be of some value	(2/8/6/5/4)
(6)	is of little value compared to inherent abilities and actual experience	(3/0/2/1/0)
(4)	other (specify) _____	

4. On the basis of your present career plans and expectations, and assuming that you would like to devote some time to continuing your education, indicate approximately the percentage of this time you would like to spend on management training, assuming

that the remainder would be devoted to furthering your technical education.

52.4 Average

100 90 80 70 60 50 40 30 20 10

5. (a) Below is a list of management training and related courses that are offered at MSC. In column (A), you are to check the courses you have taken. You are also asked to use the blank spaces for any other management training or related courses you have taken since coming to MSC.

(b) For each course you have taken, indicate in column (B) whether the course was taken--
1 - at your own initiative
2 - at your supervisor's suggestion
3 - a combination of these two

(c) For each course you have taken, indicate in column (C) whether the course was taken--
1 - to fulfill a definite need on the job you had at the time
2 - to develop abilities primarily for future use

(d) For each course you have taken, indicate in column (D) your evaluation of the course, using the following symbols--
4 - Effective in accomplishing purpose; met with my expectations
3 - I felt that I derived some benefit from taking the course, but the results were below my expectations
2 - The course was interesting, but didn't contain much material that I will be able to apply to my job
1 - I don't see how what I learned can be of very much use to me.

(A)	(B)	(C)	(D)
Basic Management Techniques I			
Basic Management Techniques II			
Communicating and Counseling			
Management and Group Performance			
Management Seminar for Executives			
Management Seminar for Supervisory Scientists and Engineers			
Middle Management Institute			
Problem Analysis and Decision-Making Seminar for Executives			
Supervision and Group Performance			
Clear Writing I			
Clear Writing II			
Conference Leadership			

(A) (B) (C) (D)

Making Effective Oral Presentations
Reading Improvement
Written Communications for Executives

Indicating have taken courses: $\frac{15}{24}$; $\frac{25}{39}$; $\frac{24}{41}$; $\frac{31}{49}$; $\frac{4}{38}$

99 of 191 = 52% have taken courses

6. Please use the space below to list any suggestions you have with respect to management education or training and development programs used or to be used for engineers and scientists at MSC.

VII. Below is a list of subjects. On the basis of your present career plans and expectations, indicate the subjects in which you feel that you have a need for further training. You may choose as many subjects as you wish, but you are asked to restrict the number of responses to courses which you feel could be of value to you in your work and in which you have a definite need for further training.

Percentage	Rank	
49% -	1 (2)	Public Speaking (making effective oral presentations)(93)
36% -	2 (7)	Written Communication (68)
39% -	3 (4)	Reading Improvement (75)
	4 ( )	Federal Personnel Administration (22)
34% -	5 (8)	Individual and Group Motivation (65)
27% -	6 (12)	Human Relations (52)
34% -	7 (9)	Principles of Organization (64)
26% -	8 (13)	Human Behavior in Organizations (50)
	9 ( )	Psychology (37)
	10 ( )	Sociology (10)
	11 ( )	Budget Preparation and Analysis (31)
	12 ( )	Operations Research Techniques (36)
	13 ( )	Economics (general theory and principles) (19)
	14 ( )	Engineering Economy (economic evaluation of engineered systems) (42)
31% -	15 (10)	Creative Thinking (60)
54% -	16 (1)	Problem Solving and Decision-Making (103)
41% -	17 (3)	Planning and Goal Setting (79)
	18 ( )	Data Processing (27)
30% -	19 (11)	Computer Applications (57)
	20 ( )	Communication: techniques in counseling, interviewing, and recruiting (36)
36% -	21 (6)	Principles of Leadership (69)
39% -	22 (5)	Elements of Supervision (74)
	23 ( )	Orientation in Government Operations (15)
36% -	24 (7)	Management of Research and Development (68)
	25 ( )	Orientation in NASA and MSC Goals, Functions, Organizations (40)
	26 ( )	Law Practices (Patents, Contracts) (23)
	27 ( )	Political Science (7)
	28 ( )	History (3)
	29 ( )	Office Management (17)
	30 ( )	Cost Accounting (9)
	31 ( )	Financial Management (21)
	32 ( )	Probability and Statistics (39)
	33 ( )	English Composition (grammar, punctuation, spelling) (15)
26% -	34 (14)	Conference Leadership (49)
	35 ( )	Specific engineering specialties (write in) (49)

36 ( ) basic sciences (write in) (45)

37 ( ) engineering methods (write in) (13)

38 ( ) miscellaneous skills (write in) (8)

APPENDIX B:

QUESTIONNAIRE RESPONSES BY SUBGROUPS

TABLE B-I.- AVERAGE PERCEIVED IMPORTANCE

Area of ability or knowledge	Second and third level managers	First level supervisors	GS-13's	GS-11's and 12's	GS-7's and 9's
1. Technical knowledge	7.2	6.6	7.2	6.9	7.8
2. MSC organizational knowledge	7.4	7.6	8.0	8.0	8.4
3. Written communication	8.2	7.6	7.8	7.8	8.2
4. Oral presentations	7.8	7.3	7.7	7.6	7.7
5. Reading	8.0	6.9	6.8	6.7	6.9
6. Conducting meetings	8.4	7.3	7.5	7.9	7.8
7. Decision-making	9.0	9.4	9.0	9.4	9.3
8. Establishing goals	8.7	8.4	8.4	8.6	8.7
9. Establishing organization structure	8.0	7.9	7.7	8.3	8.1
10. Scheduling work	8.3	8.3	7.5	8.1	8.2
11. Motivating subordinates	9.0	8.6	7.7	8.4	8.4
12. Understanding personal and interpersonal problems of subordinates	8.0	7.8	6.8	7.5	7.9
13. Coordinating and controlling	7.4	7.6	7.3	7.9	7.9
14. Developing subordinates	7.3	7.3	6.2	7.2	7.3
15. Working with superiors	9.3	8.7	8.8	8.6	8.7
16. Working with contractors	8.3	7.7	7.6	7.6	8.3
17. Personal traits	9.0	8.7	8.5	8.6	9.4

TABLE B-II.- AVERAGE SELF-EVALUATION

Area of ability or knowledge	Second and third level managers	First line supervisors	GS-13's	GS-11's and 12's	GS-7's and 9's
1. Technical knowledge	7.4	7.1	7.4	6.9	6.8
2. MSC organizational knowledge	7.7	7.1	6.6	6.5	6.0
3. Written communication	8.0	7.3	7.4	6.9	7.3
4. Oral presentations	7.8	6.2	6.4	6.1	6.8
5. Reading	7.7	5.9	6.3	6.2	6.3
6. Conducting meetings	8.2	6.5	6.3	5.7	6.3
7. Decision-making	8.4	7.4	7.4	6.9	6.8
8. Establishing goals	8.1	7.1	6.8	6.4	6.5
9. Establishing organization structure	7.6	7.2	6.9	6.0	6.5
10. Scheduling work	8.1	7.2	7.2	6.4	6.7
11. Motivating subordinates	8.6	7.0	6.7	6.3	6.7
12. Understanding personal and interpersonal problems of subordinates	7.6	7.0	7.0	6.1	7.0
13. Coordinating and controlling	7.8	7.2	6.8	6.6	6.7
14. Developing subordinates	7.6	6.9	6.3	6.3	6.7
15. Working with superiors	7.7	6.9	6.8	6.5	6.9
16. Working with contractors	8.5	7.2	7.4	7.0	7.0
17. Personal Traits	8.1	7.5	7.5	7.4	7.6

TABLE B-III.- AVERAGE EVALUATION OF SUPERIORS

Area of ability or knowledge	Second and third level managers	First level supervisors	GS-13's	GS-11's and 12's	GS-7's and 9's
1. Technical knowledge	7.7	6.9	6.5	6.5	8.0
2. MSC organization knowledge	7.4	6.9	6.4	7.1	8.4
3. Written communication	7.2	6.8	6.2	6.6	8.0
4. Oral presentations	7.5	7.1	6.7	6.5	7.8
5. Reading	---	---	---	---	---
6. Conducting meetings	6.9	6.6	6.2	6.3	7.6
7. Decision-making	6.4	5.8	5.6	6.4	8.1
8. Establishing goals	5.7	5.5	4.9	5.9	7.1
9. Establishing organization structure	4.9	5.3	4.7	5.7	7.0
10. Scheduling work	5.9	5.5	5.7	5.8	6.7
11. Motivating subordinates	5.8	4.8	4.4	5.4	6.7
12. Understanding personal and interpersonal problems of subordinates	6.0	5.2	4.6	5.3	6.4
13. Coordinating and controlling	6.4	5.7	4.9	5.5	7.2
14. Developing subordinates	5.6	5.3	4.7	5.3	6.3
15. Working with superiors	3.0	6.5	6.9	6.9	8.3
16. Working with contractors	7.6	7.0	6.8	6.9	8.1
17. Personal traits	7.8	7.9	6.9	6.6	8.5

TABLE B-IV.- PERCENTAGE OF SUB-GROUPS SELECTING SUBJECTS

Course	GS-15's and 16's	GS-14	GS-13	GS-11's and 12's	GS-7's and 9's
1. Public Speaking	26	53	52	49	55
2. Written Communication	11	33	25	38	60
3. Reading Improvement	18	43	40	36	53
4. Federal Personnel Administration	18	10	15	9	8
5. Individual and Group Motivation	37	50	29	30	32
6. Human Relations	18	37	21	28	32
7. Principles of Organization	33	47	31	38	29
8. Human Behavior in Organizations	30	30	27	25	24
9. Psychology	7	17	27	9	32
10. Sociology	7	3	4	2	11
11. Budget Preparation and Analysis	15	17	21	21	13
12. Operations Research Techniques	26	30	27	9	13
13. Economics	15	6	6	13	13
14. Engineering Economy	22	23	19	23	24
15. Creative Thinking	15	37	29	34	37
16. Problem Solving and Decision-Making	37	57	69	51	50
17. Planning and Goal Setting	18	63	33	55	34
18. Data Processing	0	7	12	17	26
19. Computer Applications	26	20	29	34	34
20. Techniques in Counseling, Interviewing, Recruiting	7	27	21	15	24
21. Principles of Leadership	11	43	44	40	34
22. Elements of Supervision	7	43	42	47	42
23. Orientation in Government Operations	4	7	8	6	13
24. Management of Research and Development	52	67	33	32	10
25. Orientation in NASA and MSC Goals, Functions, Organization	26	17	23	23	16
26. Law Practices (Patents, Contracts)	15	7	10	21	3
27. Political Science	7	0	4	4	3
28. History	4	0	4	0	0
29. Office Management	0	10	12	11	5
30. Cost Accounting	0	7	6	4	5
31. Financial Management	18	13	14	8	5
32. Probability and Statistics	22	13	19	25	21
33. English Composition	0	3	6	11	13
34. Conference Leadership	15	43	29	23	18
35. Engineering Specialties (write in)	18	30	19	25	37
36. Basic Sciences (write in)	15	20	12	21	42
37. Engineering Methods (write in)	18	3	2	2	13
38. Miscellaneous Skills (write in)	0	3	2	9	3